H SAF
Support to Operational Hydrology and Water Management

Recent developments within H-SAF in the context of the GPM

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with

H-SAF Precipitation Product Development Team

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*F. Porcù – **University of Bologna, Italy***
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*Pier Baguis, Emmanuel Roulin – Royal Meteorological Institute, **Belgium***
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and
*Luca Brocca, L. Ciabatta, C. Massari, **CNR-IRPI, Italy***

EUMETSAT SAF on Support to Operational Hydrology and Water Management

http://hsaf.meteoam.it

USAM/CNMCA, Italy: H-SAF management, and data service

Objectives:

- **1) To provide operational high quality level 2/3 products and develop new products from existing and future satellites with sufficient time and space resolution to satisfy the needs of operational hydrology;**
  - **precipitation** (liquid, solid, rate, accumulated); Leader, Italy (**ISAC-CNR, CNMCA**);
  - **soil moisture** (at large-scale, at local-scale, at surface and in roots region); Leader Austria (**TU-Wien**);
  - **snow parameters** (detection, cover, melting conditions, water equivalent); Leader Finland, Turkey)
- **2) To provide indipendent validation to verify the usefulness of the products for civil protection purposes (floods, landslides, etc..), and for monitoring water resources, and the impact in hydrological models.**
  - *Quality monitoring:* 12 countries involved: Austria, Belgium, Bulgaria, ECMWF, Finland, France, Germany, Hungary, Italy, Poland, Slovakia, Turkey; coordinated by **DPC (Italy)**
  - *Hydrovalidation:* 8 countries involved : Poland, Belgium, Bulgaria, Finland, Germany, Italy, Slovakia, Turkey; 21 test sites provided; coordinated by **IMGW (Poland)**

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GPM
GLOBAL PRECIPITATION MEASUREMENT

No-cost proposal approved in 2014 by the NASA PMM Research Program

"H-SAF and GPM: precipitation algorithm development and validation activity"

- Long term collaboration between EUMETSAT H-SAF and GPM on the following aspects:
  - •***precipitation retrieval algorithm development***, through a fruitful interaction on several critical aspects of interest both to H-SAF and GPM (**ISAC-CNR, CNMCA**); ***Scientific coordinator: Giulia Panegrossi (ISAC-CNR)***
  - •***validation activity***, through the connection between the well established H-SAF product validation (**DPC, IMGW, and PPVG)** and hydrological validation ((**IMGW**) programs and the Ground Validation/Calibration activity of GPM**;** ***Scientific Coordinator: Silvia Puca (DPC)***
- **Participation of H-SAF to GPM EM phase and beyond:**
  - •Daily download of "Europe" subset of GPM products
  - •Analysis of case studies and validation over Europe of GPM products
  - •Algorithm development for GPM constellation

Overview of recent H-SAF activity in the contest of GPM

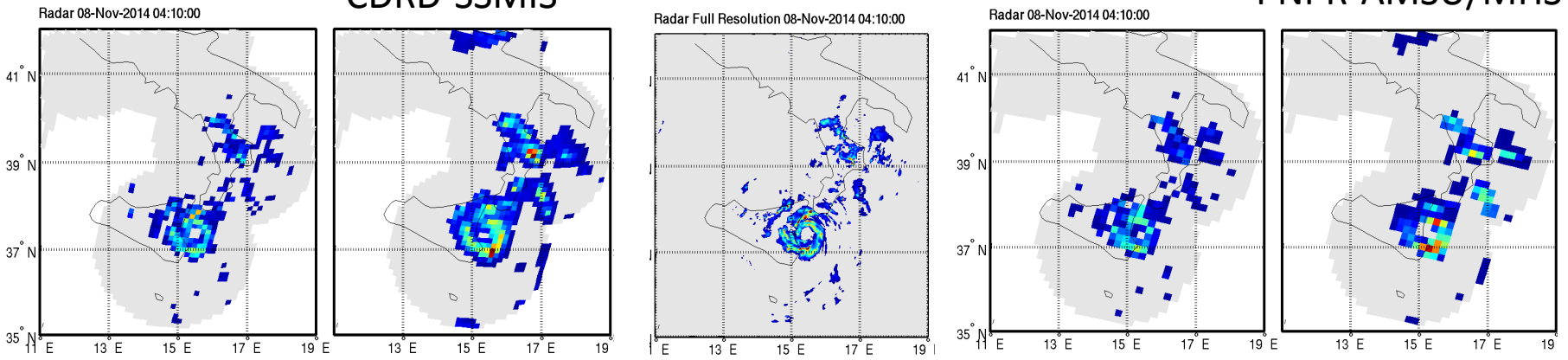
- Validation of GPM products over Europe (results presented at last GPM GV meeting in South Korea);
  - Validation of 1 year GPROF-GMI:
  - Comparison of GPROF-SSMIS and GPROF-MHS with H-SAF PMW products on selected case studies;
  - Prospectives in H-SAF hydrological validation

POSTER #205, Wednesday!

Medicane, Sicily, November 8, 2014

CDRD-SSMIS

PNPR-AMSU/MHS



Overview of recent H-SAF activity in the contest of GPM

- **H-SAF Algorithm Development in CDOP-2**
  - Extension of precipitation products to MSG to full disk:
    - Verification study over Africa of H-SAF PMW products
  - Exploitation of GPM constellation within H-SAF
    - New algorithm for ATMS, GMI, AMSR-2;
    - Level 3 PMW combined daily precipitation;

- **Integration of the Soil Moisture derived products with H-SAF and GPM rainfall products (collaboration with L. Brocca, CNR-IRPI)**

- **H-SAF/SSEC/UMBC Federated activity proposal (approved May 2015):**
  - Use of active and passive spaceborne observations for optimal exploitation of high frequency channels for PMW snowfall and light precipitation retrieval at high latitudes;

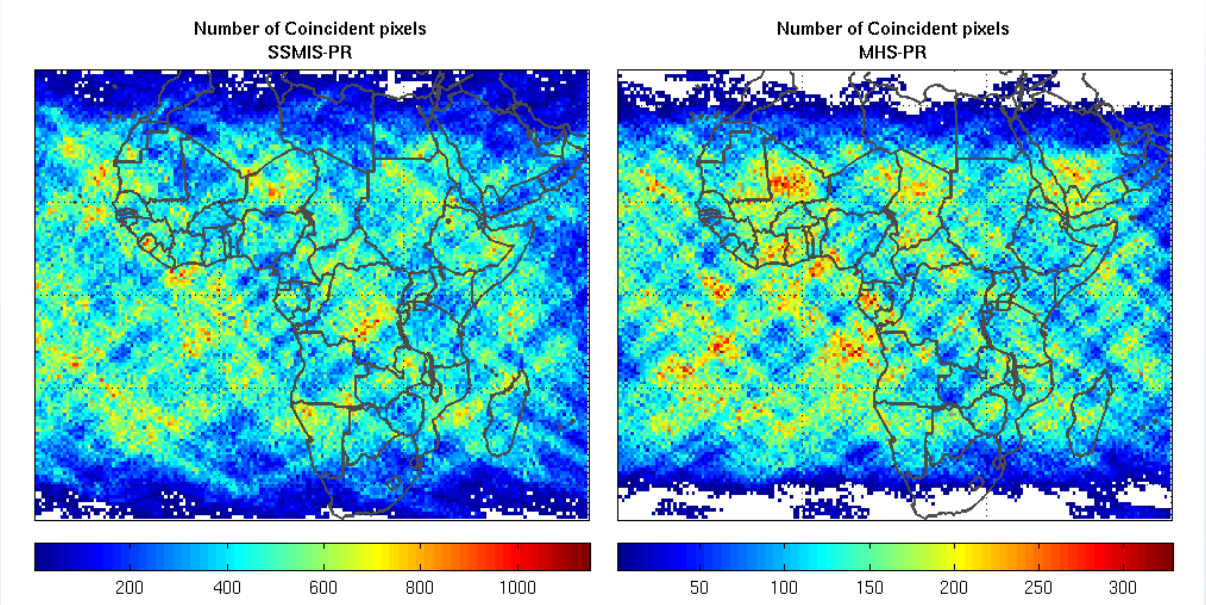
H-SAF Currently Operational Precipitation Products for NRT applications

	Area	Description	Main features
H01 (CDRD Algorithm) **Casella et al., TGRS, 2013, Sanò et al., TGRS 2013)**	H-SAF (25-75ºN / 25ºW-45ºE) Full MSG Disk	**Precipitation rate at ground from SSMIS (with indication of phase)** **Bayesian approach** **Spatial resolution: 15.5x13.2 km^2**	• **Same Physical Foundation (Cloud-radiation model simulations, screening procedure)** • **Recently extended to Africa and Southern Atlantic** • **Improved detection over arid surface (Casella et al., AMT, 2015)** • **Quality Index, Precipitation Phase**
H02A/B (PNPR Algorithm) **Sanò et al., AMT, 2015)**	H-SAF (25-75ºN; 25ºW-45ºE) / Full MSG Disk	**Precipitation rate at ground from AMSU-A/MHS (with indication of phase)** **Neural Network approach** **Spatial resolution: variable with scan angle (16x16km^2 at nadir)**	

H-SAF
PMW Products in development during CDOP-2 for exploitation of GPM constellation

	Coverage Area	Description
H17	Full MSG Disk	CDRD based Bayesian retrieval for GCOM-W1 AMSR-2
H18	Full MSG Disk	**Cloud-radiation model based ANN algorithm for NPP Suomi ATMS**
H19	Full MSG Disk	Cloud-radiation model based algorithm for GMI
H20	Global (65 S – 65 N)	ANN trained using GMI and DPR global coincident observations dataset
H22	Full MSG Disk	Snowfall intensity Input: AMSU-B/ MHS
H51	Full MSG Disk	Level 3 PMW daily precipitation (from combined and regridded PMW products)

Extension to Africa and Southern Atlantic Verification study using TRMM-PR



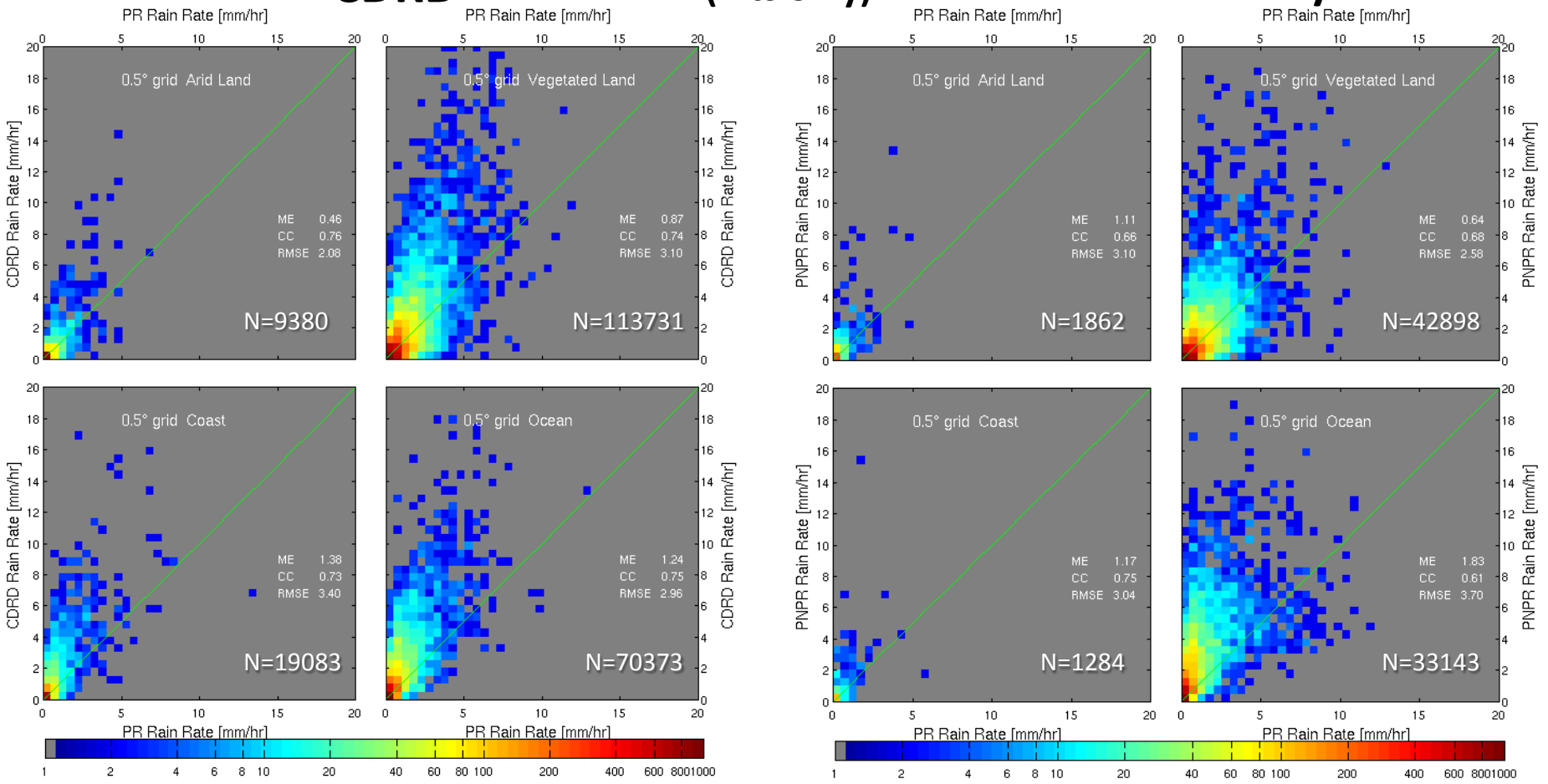
TRMM PR-PMW coincidence dataset

Study area:
36° S–36° N
60° E–30° W

- All the analyses were performed using coincident observations (15 min time window) of the Tropical Rainfall Measuring Mission (TRMM) precipitation Radar (PR) with observations from SSMIS, AMSU/MHS radiometers for the years 2011–2013 and with ATMS for 2013-2014.
- To obtain co-located rainfall estimates (from SSMIS,AMSU/MHS, and ATMS) and PR (TRMM product 2A25), we have averaged the TRMM-PR data to the MW radiometers nominal resolutions.
- The statistics have been computed on a regular grid at 0.5°x0.5°resolution

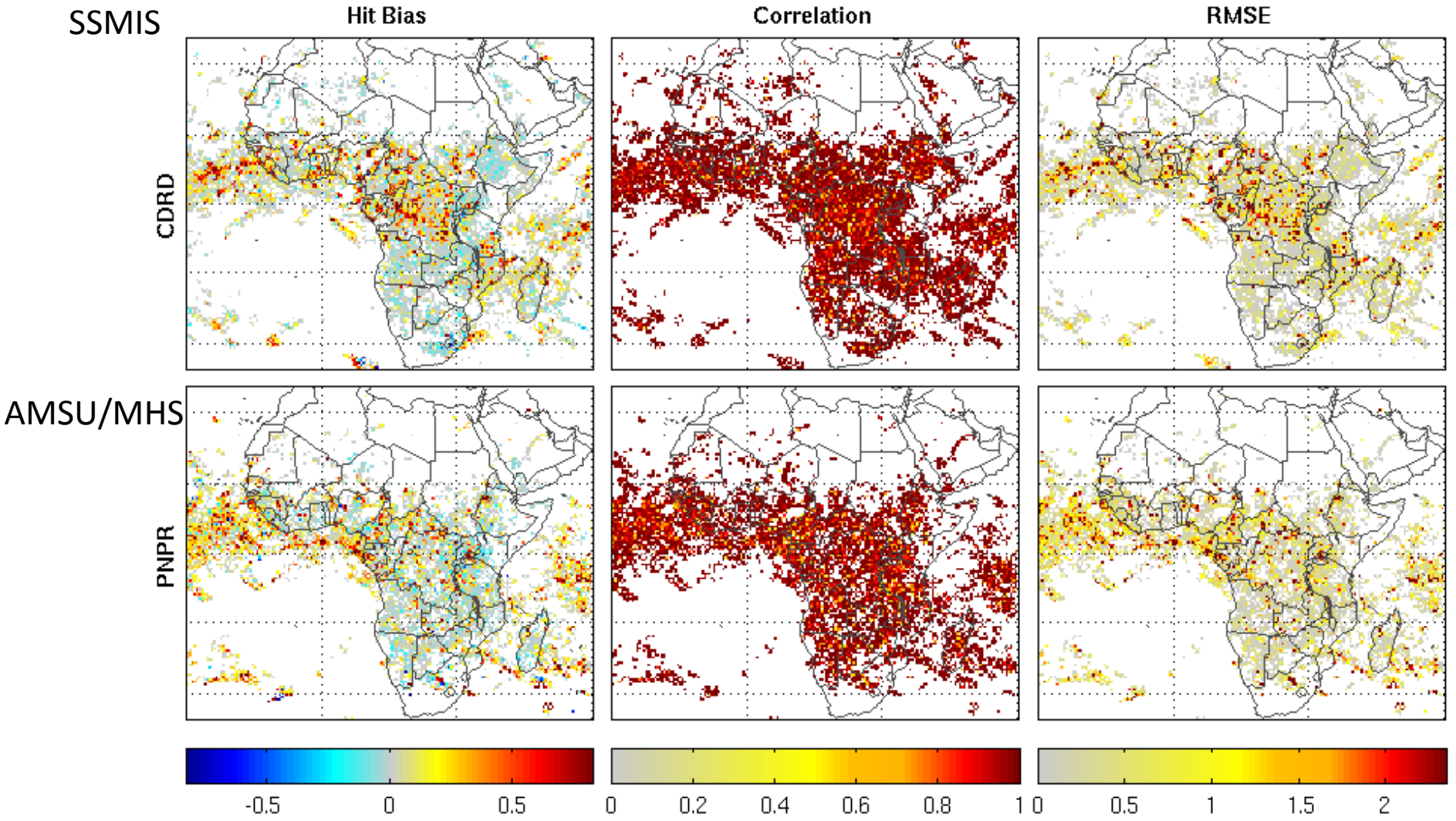
Quantitative Comparison with TRMM-PR: different background surfaces

CDRD **(hits only)** **PNPR-AMSU-A/MHS**



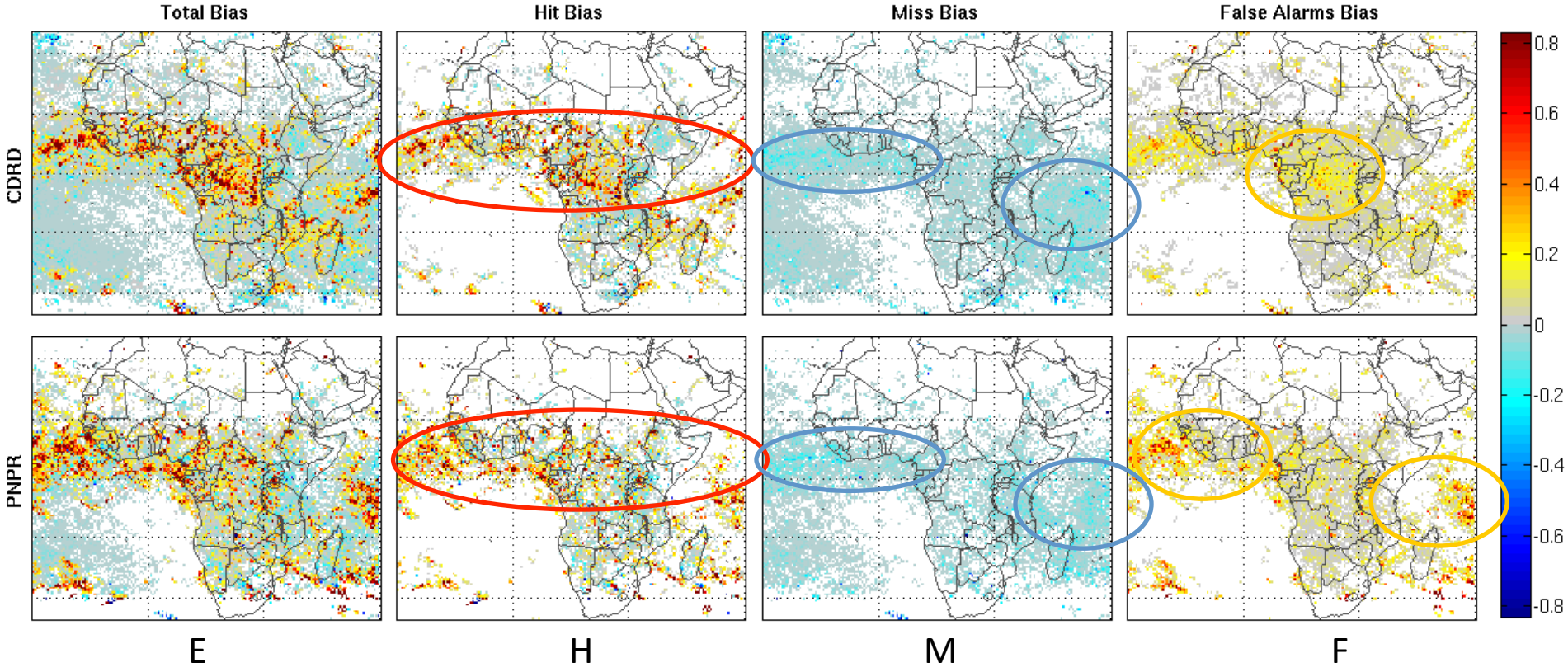
N = number of hits at PMW pixel resolution

Quantitative Comparison with TRMM-PR: maps of statistical scores



Quantitative Comparison with TRMM-PR: maps of error components

The error decomposition allows us to better identify the error sources and their contributions to the total errors.



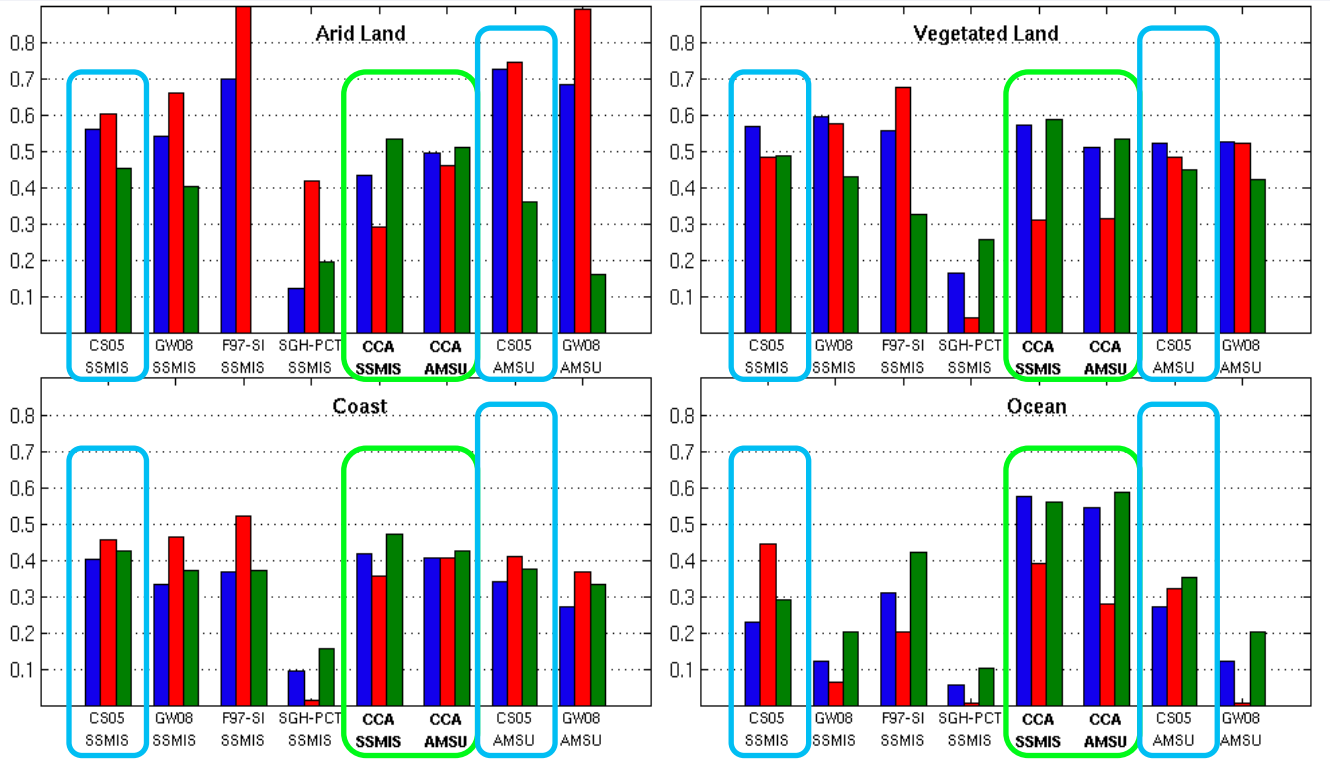
(SSMIS top panels
AMSU/MHS bottom panels)

Following Tian et al., JGR, 2009: E=H-M+F

New Precipitation Detection Algorithm

D. Casella, G. Panegrossi, P. Sanò, L. Milani, M. Petracca, and S. Dietrich, A novel algorithm for detection of precipitation in tropical regions using PMW radiometers, AMT, doi:10.5194/amtd-7-9237-2015.

Algorithm based on the application of canonical correlation analysis (**CCA**), in order to select the linear combination of TBs which has the **maximum correlation with rain rate**, and on the **definition of a threshold to discriminate rain/no rain pixels**.



Comparison of the CCA-SSMIS and CCA-AMSU algorithm with other precipitation detection algorithms with rain/no-rain threshold (truth from PR 2A25) equal to 0.1 mm/hr.

CS05
Chen and Staelin (TGRS, 2003)
GW08
Grody and Weng (TGRS, 2008)
F97-SI
Ferraro JGR, 1997
SGH-PCT
Spencer et al. JAOT, 1989

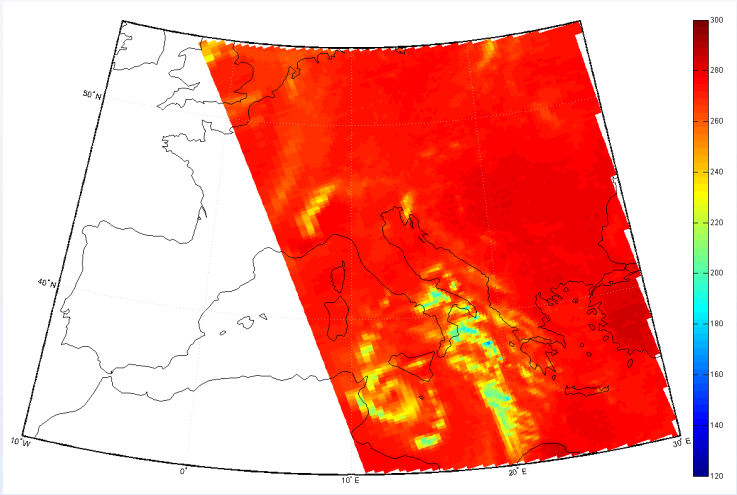
PNPR algorithm for ATMS

Main differences with respect to PNPR-AMSU/MHS:

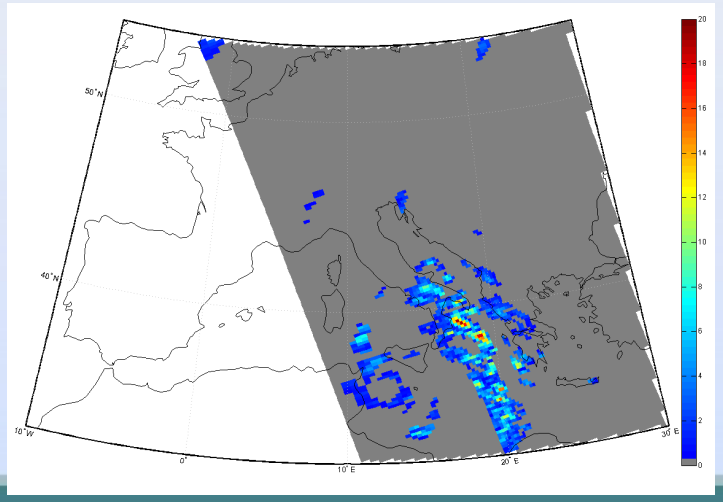
- New fully redesigned ANN to exploit the European and African database using a single ANN.
  - The PNPR-AMSU/MHS algorithm uses two different ANNs for the European and African area.
- Exploitation of some of the new ATMS channels.
  - Use of the 31 GHz channel combined with 89 GHz and 165 GHz channels (CCA approach) to improve the rain rate estimation accuracy over ocean.
  - Use of the difference between the 183±1.8 GHz and 183±4.5 GHz.
- Use of monthly mean TPW to drive ANN in the transition between the Europen and African area:
  - ECMWF reanalysis 2011-2014 period used for training the ANN;

Medicane: November 7, 2014

ATMS TB at 165 GHz [K]



ATMS PNPR RR [mm/h]



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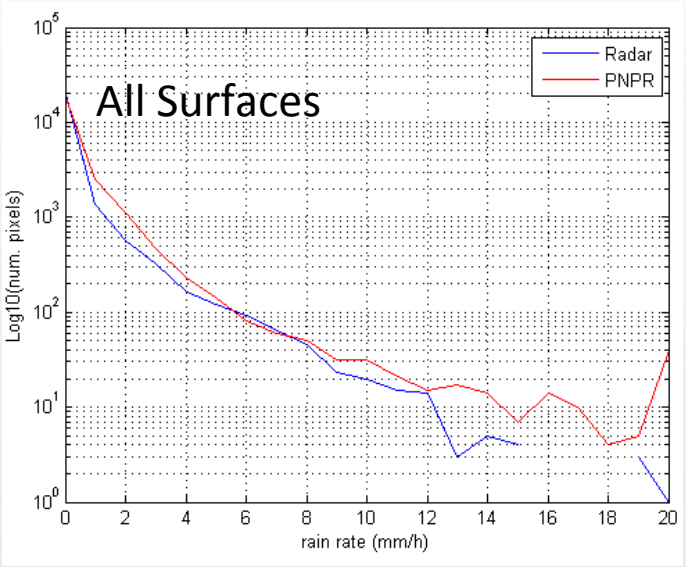
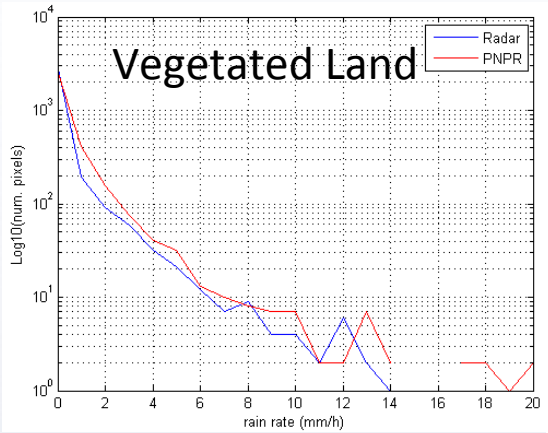
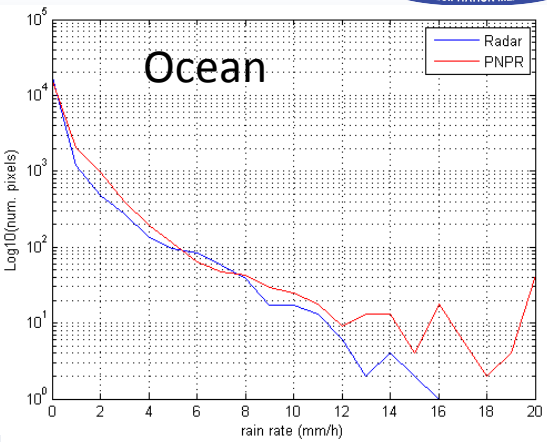
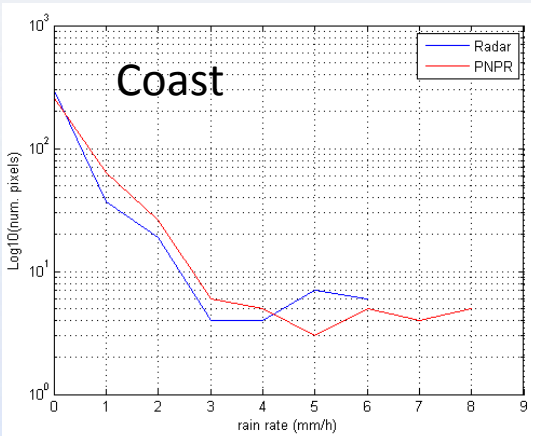
PDF's of **ATMS (PNPR)** and **TRMM PR (2A25)** rainfall rates

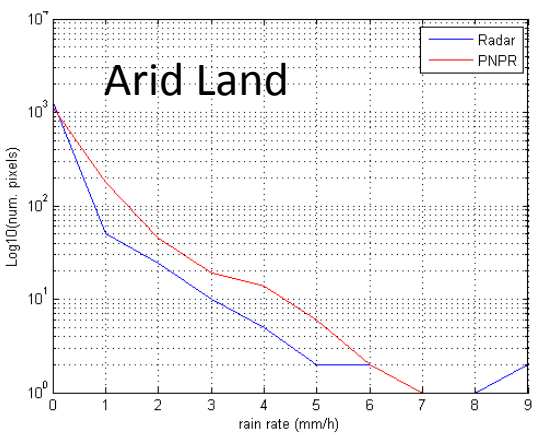
Study area:
36° S–36° N
60° E–30° W











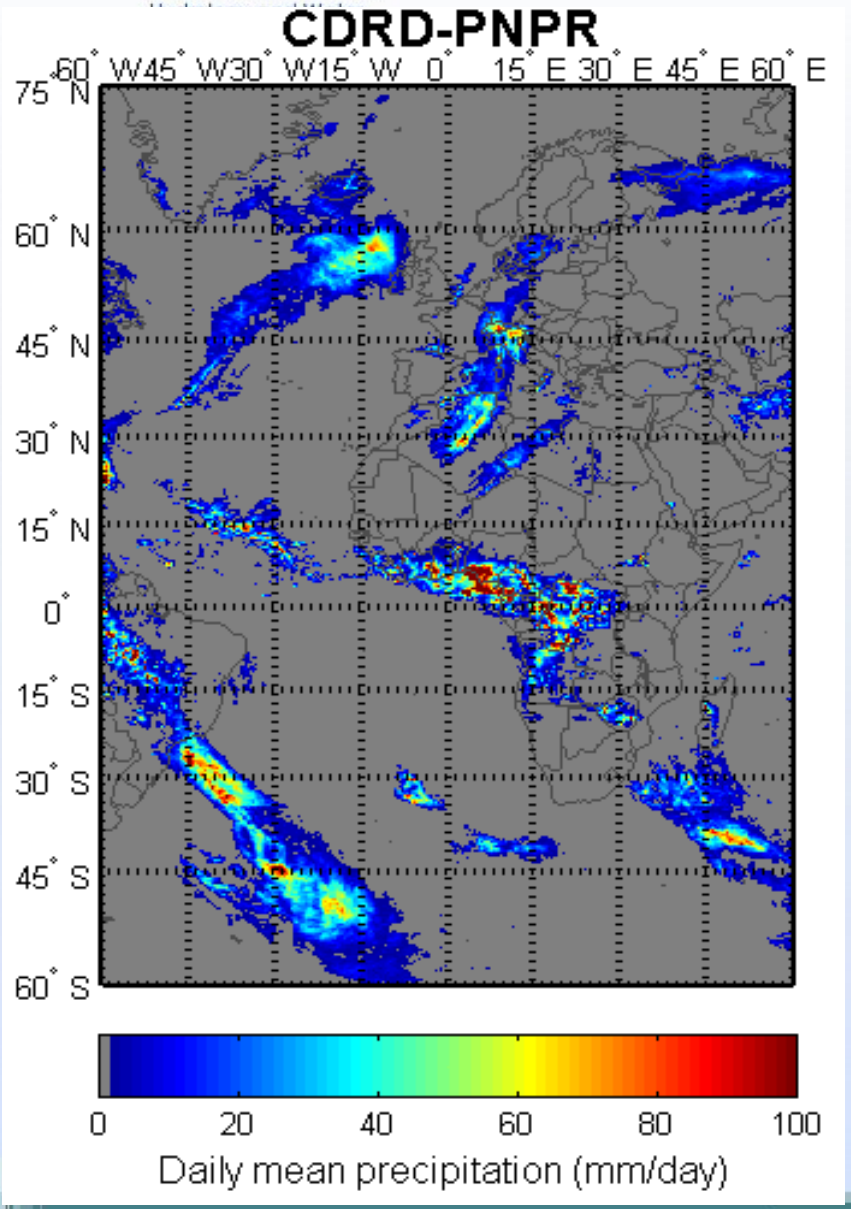
ATMS
coincidence dataset
2013-2014

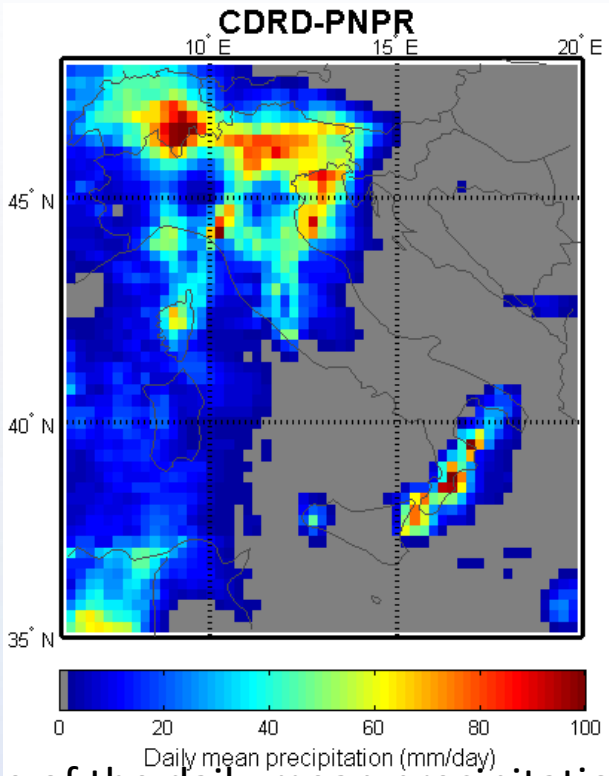
AMSU/MHS
coincidence dataset
2011-2013

Comparison with **AMSU/MHS** amd **ATMS** statistics PR > 0.20 mm/h

	LAND	OCEAN	COAST	DESERT
ME	0.64/**0.23**	1.83/**0.50**	1.17/**0.60**	1.11/**0.22**
RMSE	2.58/**2.32**	3.70/**2.87**	**3.04**/3.10	3.10/**1.82**
CC	**0.64**/0.56	**0.61**/0.43	**0.75**/0.46	**0.66**/0.47

H-SAF Level 3 PMW products





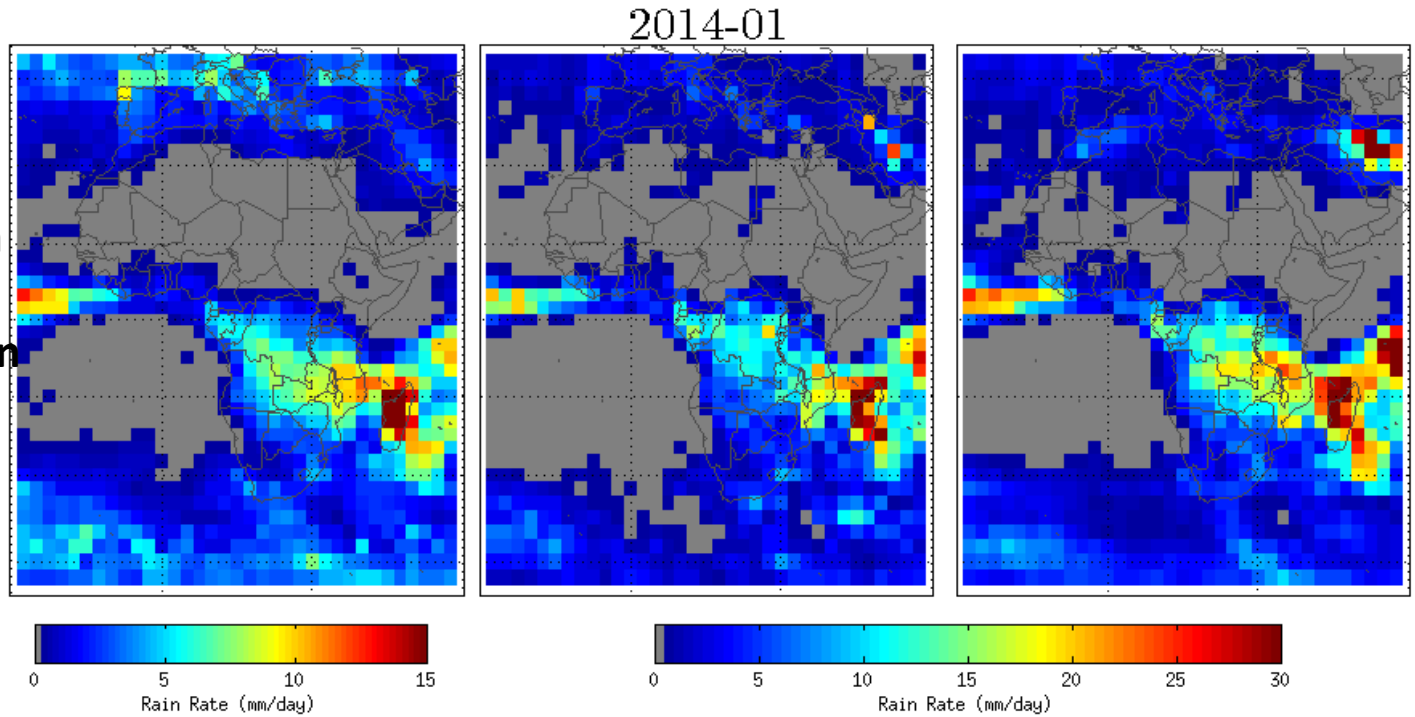
Example of the daily mean precipitation over the MSG full disk area (LAT 60°S - 67.5°N, LON 60°W - 60°E) (a) and over Italy (b) obtained combining CDRD (H01 -SSMIS) and PNPR (H02 - AMSU/MHS) retrievals on November 5, 2014, when heavy precipitation events and floods occurred over Southern Italy (Sicily and Calabria regions) and Northern Tuscany

H-SAF Level 3 PMW products

Gridded (Level 3) PMW precipitation averages (3 hourly, daily, and monthy) obtained from CDRD and PNPR instantaneous estimates available for all DMSP SSMIS and MetOP and NOAA AMSU/MHS satellites

GPCP **CDRD** **PNPR**

2014 mean monthly precipitation



GPCP SG monthly precipitation at 2.5°x2.5° compared with Level 3 CDRD and PNPR monthly precipitation (regridded at 2.5°x2.5° for comparison)

Huffman G.J., D.T. Bolvin, R.F. Adler, 2012, last updated 2012: GPCP Version 2.2 SG Combined Precipitation Data Set. WDC-A, NCDC, Asheville, NC. Data set accessed at ftp://precip.gsfc.nasa.gov/pub/gpcp-v2.2/psg/

Verification of Level 3 products over the Italian territory and integration with the Soil Moisture derived precipitation product SM2RAIN

(Collaboration with L. Brocca, CNR-IRPI, Italy)

SM2RAIN concept: The soil moisture variations are strongly related to the amount of rainfall falling into the soil. Therefore, soil moisture observations are used for estimating rainfall by considering the "soil as a natural raingauge" (***see Brocca et al., GRL, 2013, Brocca et al., JGR, 2014,*** http://hydrology.irpi.cnr.it/people/l.brocca)

- Rainfall estimations have been compared to the national raingauge network dataset. All data have been resampled on a regular grid at 0.25 for a total of 528 grid-boxes over the Italian Territory.
- Integration with SM2RAIN leads to significant improvements of results.

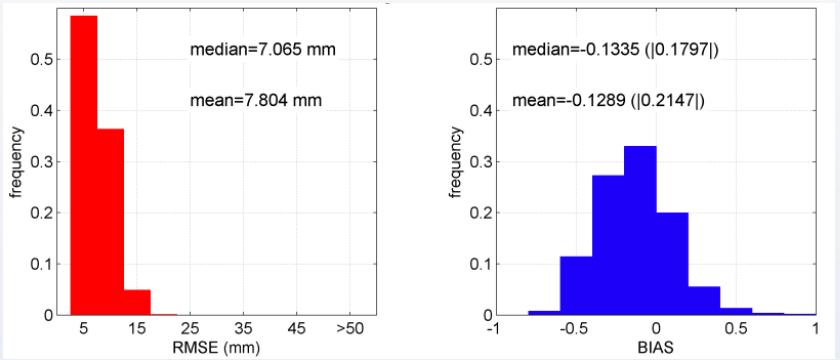
Some of the analyzed datasets 1-day or 5-day precipitation:

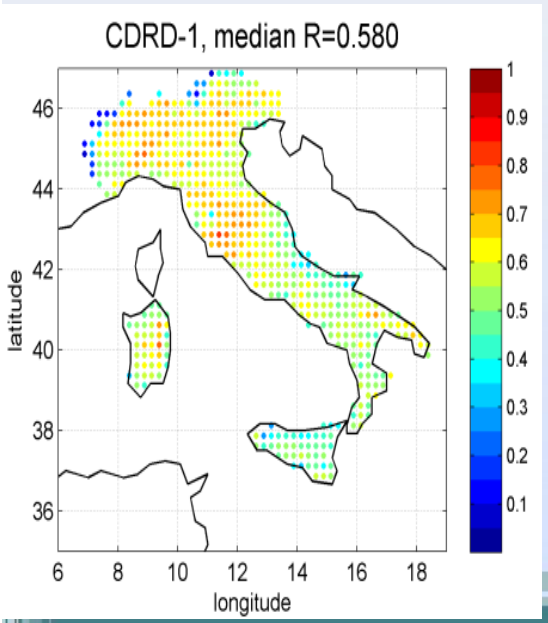
- **CDRD (2011-2014);**
- **PNPR (2011-2014);**
- **CDRD+PNPR (2011-2014);**
- **CDRD+PNPR+SM2RAIN (2011-2013);**
- **TMPA 3B42-RT (2011-2013);**
- **3B-HHR Final Run IMERG (Apr. – Dec. 2014)**
- **3B-HHR Final Run IMERG + SM2RAIN (Apr. – Dec. 2014)**

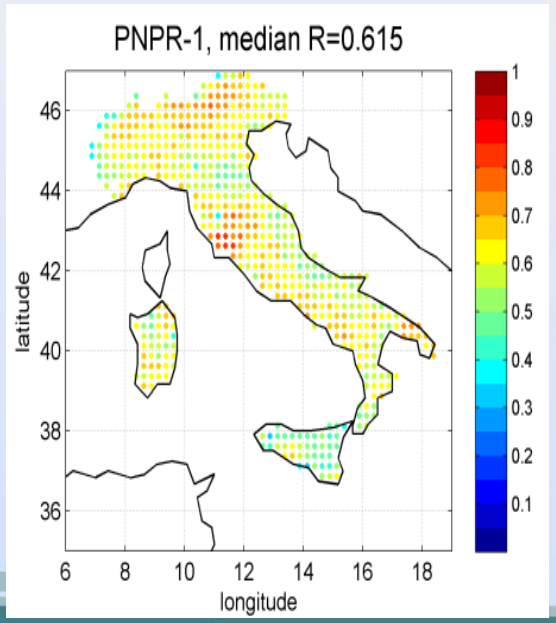
Level 3 CDRD+PNPR over Italy 2011-2014

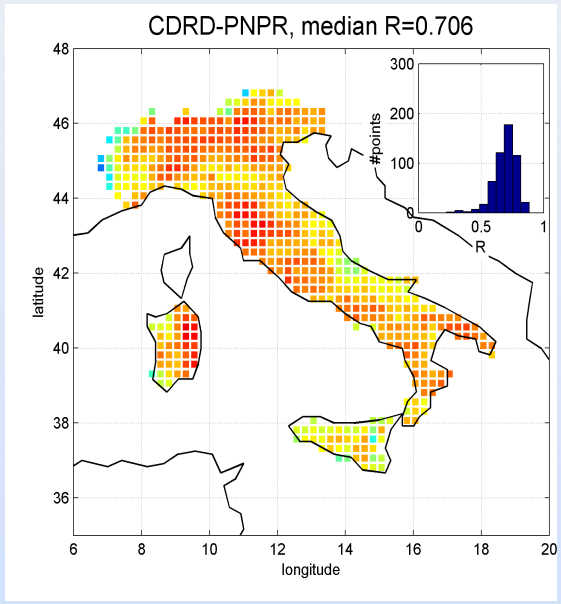
Four years precipitation retrieval from SSMIS DMPS and AMSU/MHS NOAA MetOp

Correlation coefficient for PMW (gridded) daily mean precipitation (CDRD, and PNPR and CDRD+PNPR) and daily precipitation available for the Italian rain gauge network;



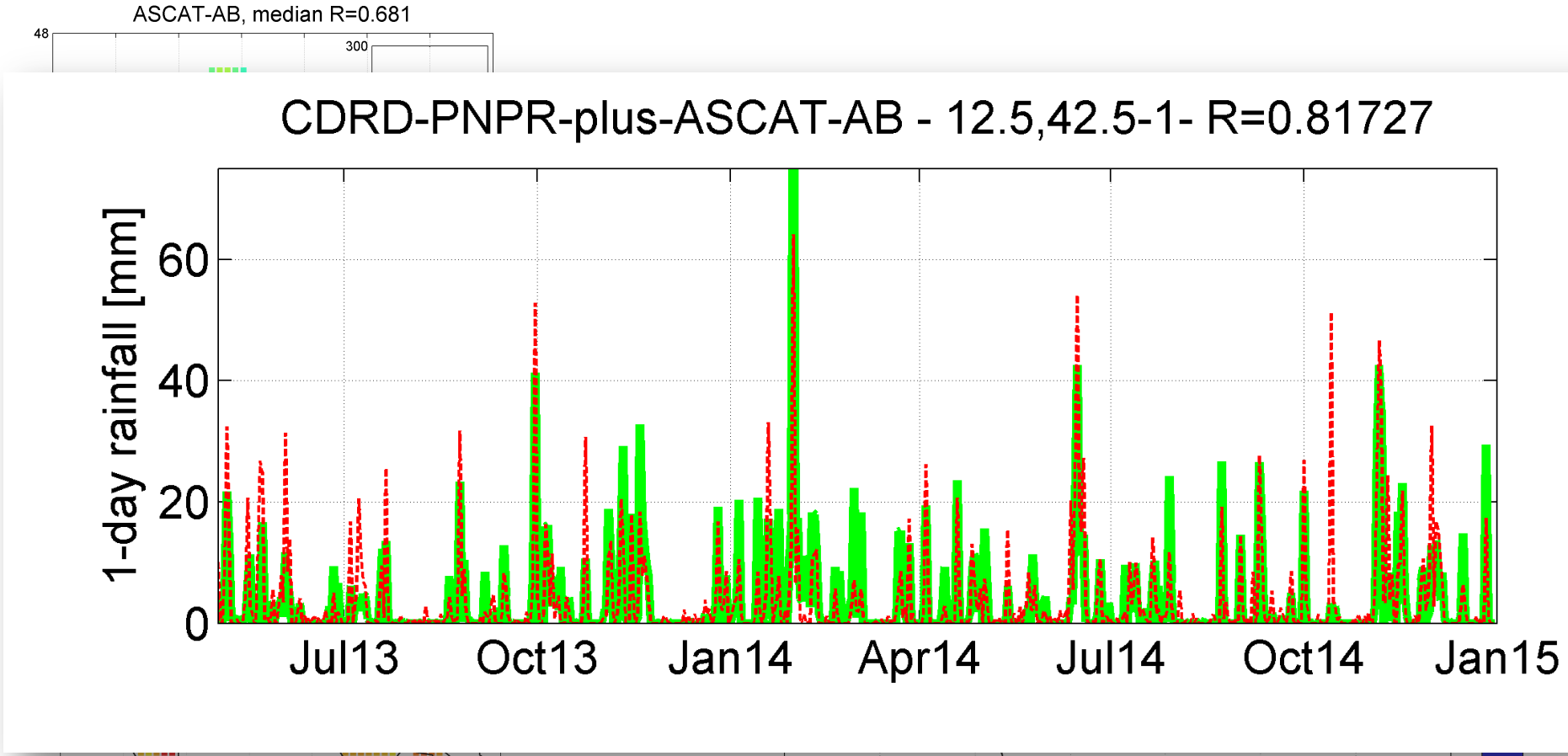






ASCAT SM+H-SAF in Italy

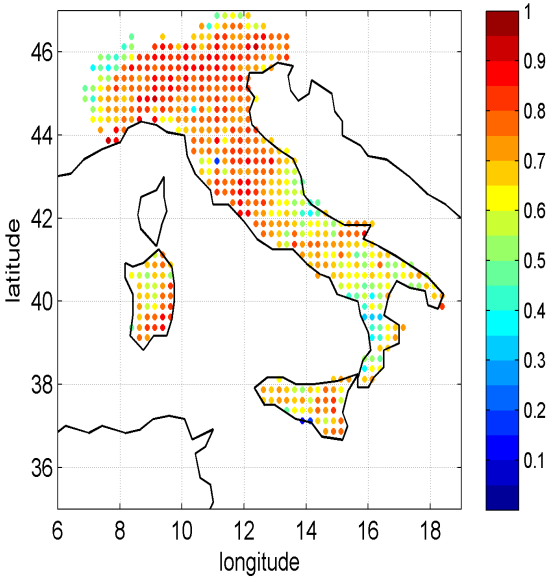
SM2RAIN from ASCAT SM data MetOp-a and MetOp-B



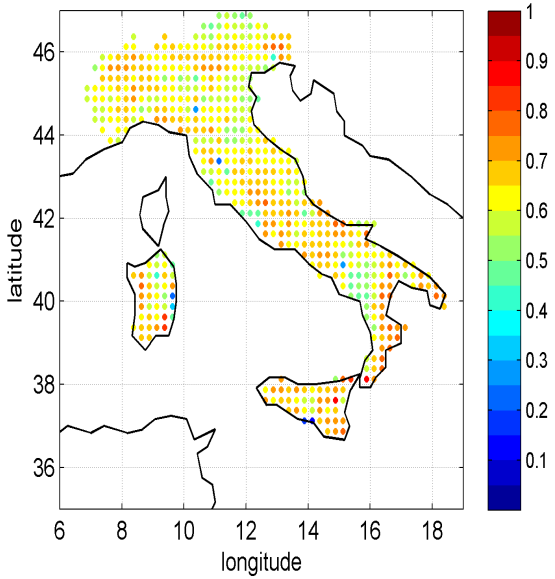
CDRD+PNPR

Integration between 3B-HHR Final Run IMERG product and SM2RAIN during the period 1-Apr-2014/31-Dec-2014

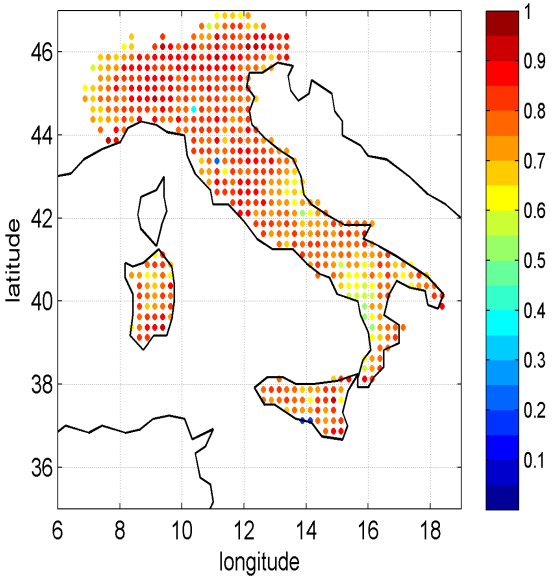
IMERGE



SM2RAIN



IMERGE+SM2RAIN



Hydrological Applications

(*Ciabatta et al., J. Hydromet., 2015***)**

Discharge simulations using H05+SM2RAIN

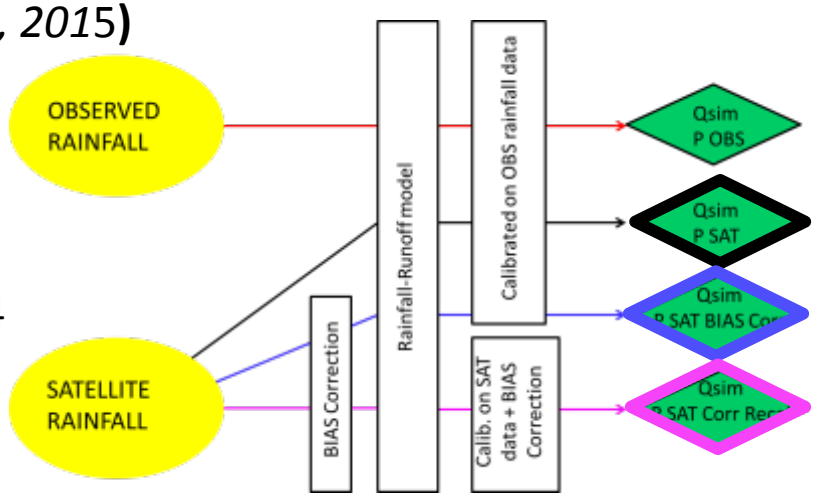
Nash–Sutcliffe model efficiency coefficient [-∞; 1]

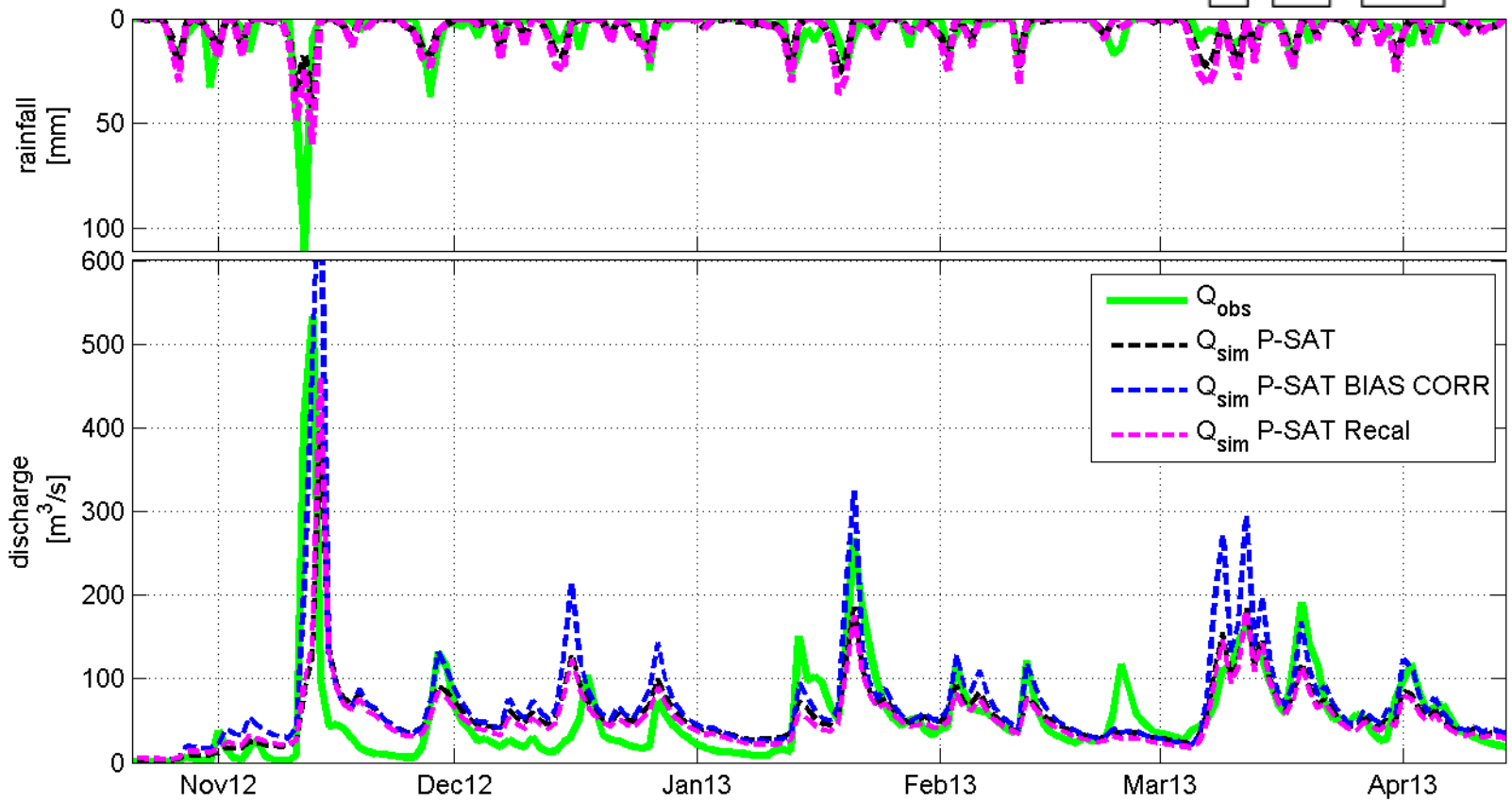
NS Qsim P-OBS=0.46

NS Qsim P-SAT=0.29

NS Qsim P-SAT Bias Correction=0.44

NS Qsim P-SAT Recal=0.52





Federated Activity with PMM Science Team
H-SAF, SSEC/UW-Madison, UMBC-JCET(?)
(approved May 2015)

Main Goal:

Prepare and exploit datasets from coincident overpasses of spaceborne precipitation radars and PMW radiometers for the refinement and development of precipitation retrieval techniques with focus on light precipitation and snowfall

- Task 1: study relationship between **PMW measurements and DPR and/or CPR** measurements and products to define the limitations and capabilities of each sensor to observe **snowfall and light precipitation** (in particular at high latitudes);

- Task 2: defining strategies for **refinement of the physical assumptions** in the generation of the **cloud-radiation database** used in the retrieval algorithms **(in particular high frequency channels)** exploiting the information available from the observational datasets.

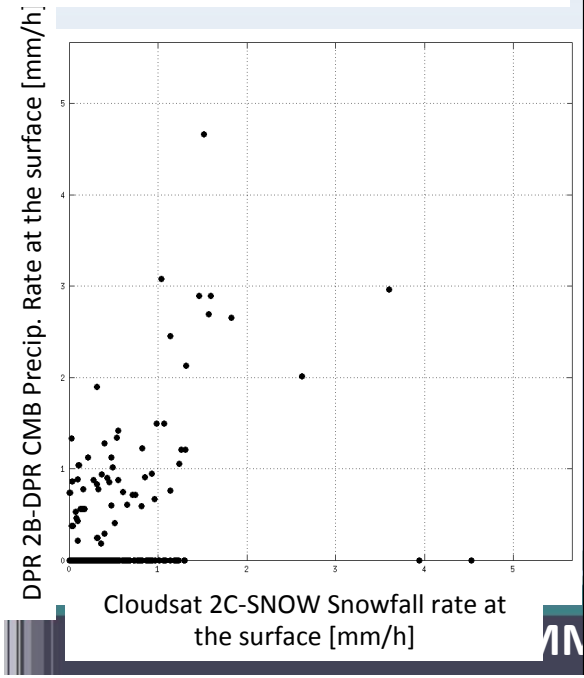
First results

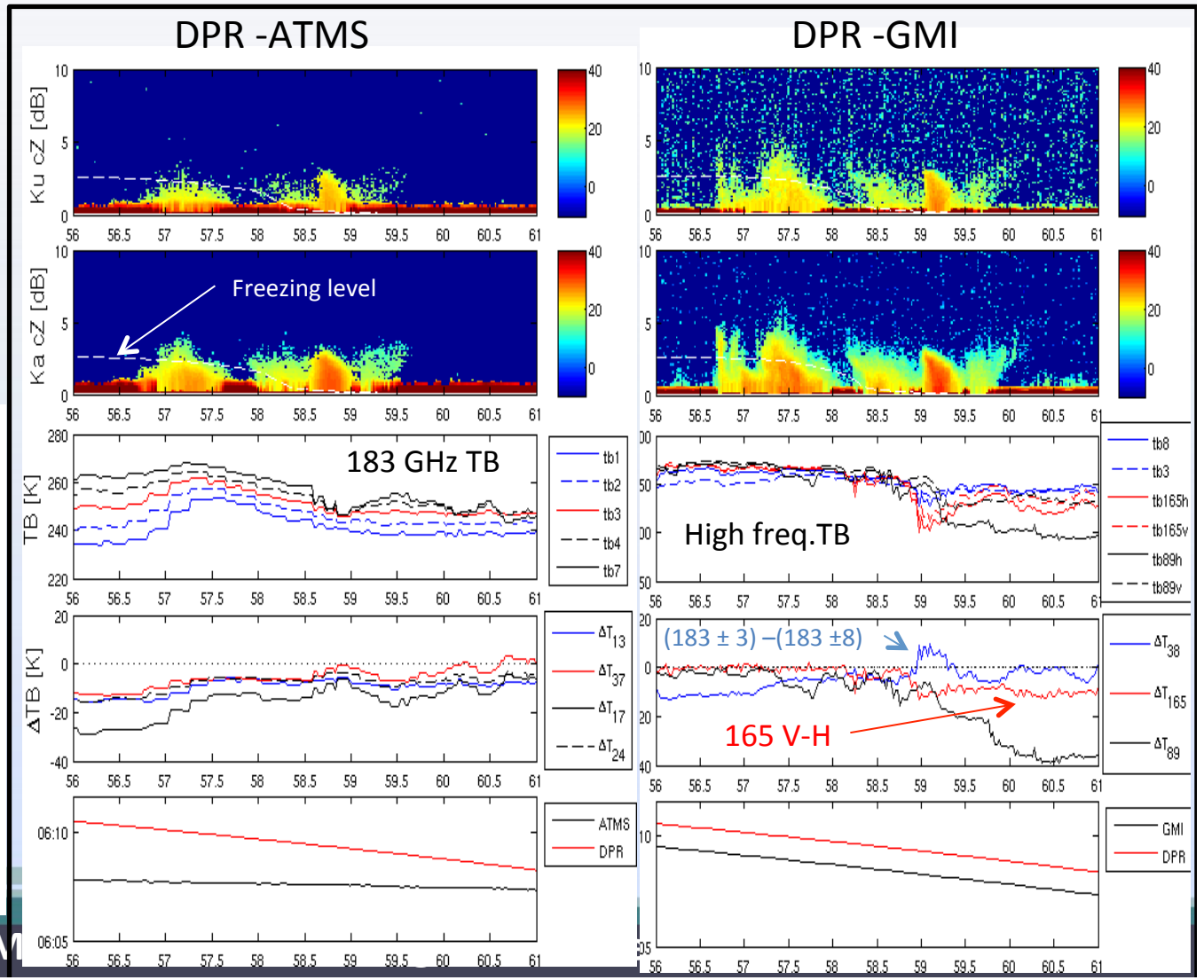
Snowfall Case study near Greenland 2015/01/18

Coincidence datasets:

- ATMS/DPR
- CloudSat-DPR
- CloudSat-AMSU/MHS

Cloudsat – DPR Coincident Observations dataset (snowfall cases)





Future perspectives

- Extension and improvement of database to full MSG disk area (Ocean and Brazil); use of coincidence datasets with TRMM-PR, GPM-DPR, and ground-based observations (collaboration with INPE/CPTEC);
- Improvement of TB simulation at high frequency (using also DPR and CloudSat coincidences with PMW radiometers) (collaboration with PMM Science Team, SSEC/UW-Madison, UMBC);
- Extension of verification study/intercomparison at mid/high latitudes using coincidence datasets with GPM DPR;
- **CDOP-3 phase of H-SAF** (2017-2022, proposal in preparation): Day-1 precipitation retrieval algorithms for EPS-SG MWI, MWS, and MWI+ICI

References

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